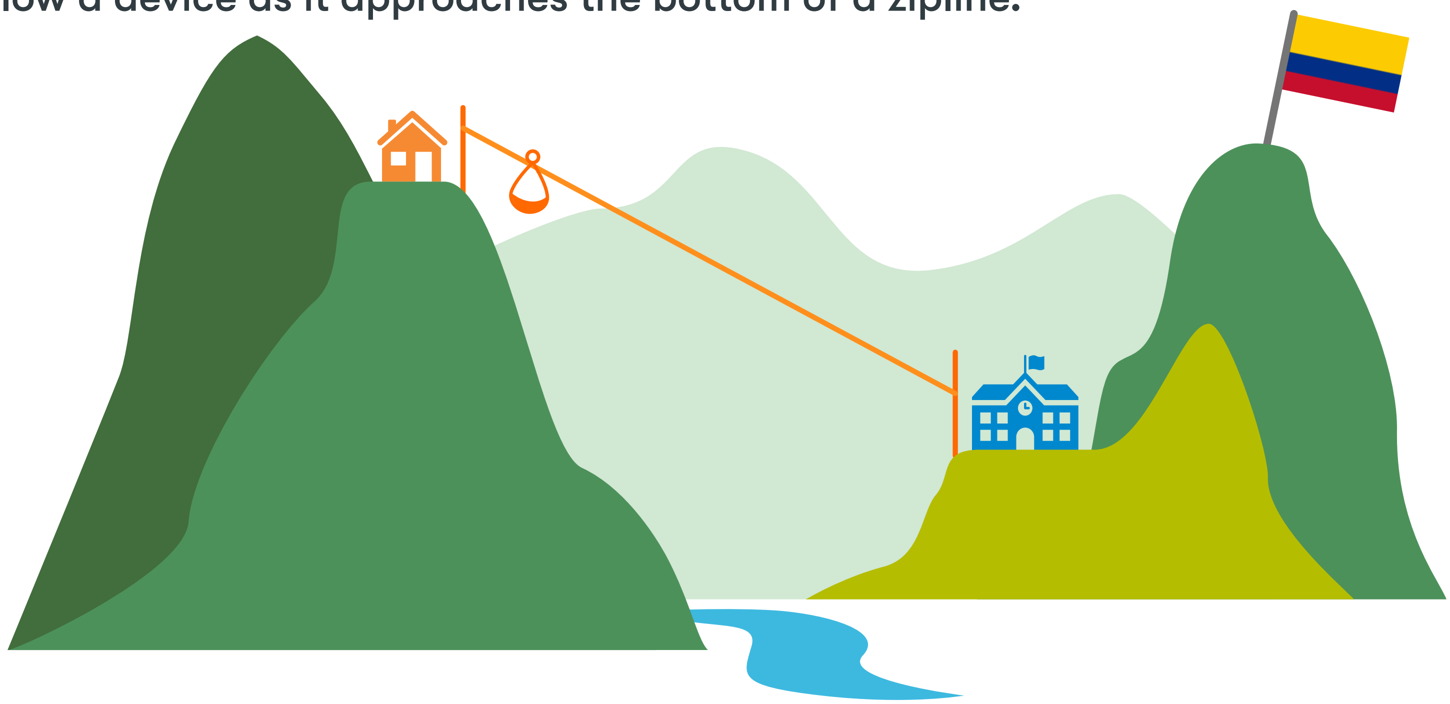
LESSON

Taking a Zipline to School

Sensemaking Lesson from The Tech Interactive

Grade Levels: 3-5 | Duration: 90 min

Students will use ideas about pushes and pulls (forces) to design a system to slow a device as it approaches the bottom of a zipline.



Outline

Frame the Activity	45 min total
Introduce the Phenomenon	10 min
Exploring the Phenomenon	10 min
Materials Investigation	15 min
Developing Possible Solutions	10 min
Design Challenge	**45 min total**
Prototype (Create and Test)	30 min
Sharing Solutions	10 min
Debrief	5 min

Grade Levels: 3-5

Duration: 90 min

Concepts/Skills

Forces, balanced and unbalanced forces, gravity

Objectives

Students will:

- Identify the need for a process to slow a zipline device.
- Identify criteria and constraints of the slow-the-device process.
- Apply ideas about forces to design, test, and revise a slow-the-device process using provided materials.
- Evaluate the different solutions (processes) based on test results, to determine which of them best solves the problem, given the criteria and the constraints.

Materials and Preparation

Materials

- Chart paper (2 pieces)
- Markers (2-3)
- Device to project the videos
- **Zipline Project packets** (1 per student)

Building Materials

Look for items that match the categories; see the suggestions below for ideas. Try to provide several different types of items for each category. Keep in mind that devices may fall from a height, so materials should be durable.

Per class of 32 students:

Structural Pieces *(50+ total)*	**Fasteners** *(100+ total)*	**Bases** *(50+ total)*
• Chopsticks • Disposable utensils • Hangers • Plastic bottle caps • Ribbon spools • Straws	• Binder clips • Binder rings • Clothespins • Paper clips • Pipe cleaners • Plastic clips • Plastic laundry hooks • Rubber bands • Twist ties	• Cardboard • Coffee filters • Empty food to-go containers • Fabric • Paper cups and bowls

Tip: Don't use glue and limit the use of tape. This allows for faster iteration, more reuse of materials, and less mess.

Tools *(One set per team)*	**Test Area Supplies** *(Per class)*
• Hole punch • Paper and pencils • Scissors • Passenger or other payload, 2-3 per team (*e.g.*, small plushie, toy people, etc.)	We recommend setting up one zipline for every three groups to avoid crowding (*e.g.*, six groups = two ziplines). Use a smooth, sturdy material for your zipline. • 5-24 ft (1.5-7.3 m) of string (*e.g.*, clothesline, fishing line, kitchen twine) OR • 5-11 ft (1.5-3.3 m) stick or rod (*e.g.*, broom handle, curtain rod, dowel)

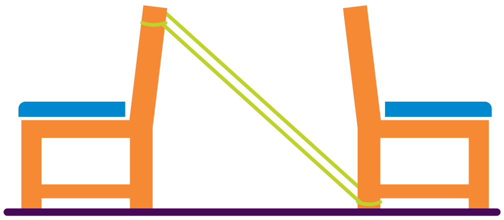
Materials Tech Tip

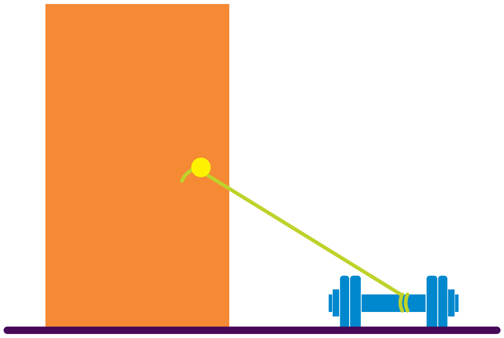
At The Tech Interactive, we generally set up the materials for this activity buffet-style so that learners can explore lots of options for building their vehicle. To avoid crowding and minimize mess, try setting up each category of material in different parts of the room and encourage teams to start with a smaller number of materials.

For more strategies on managing materials in design challenges, see our **Explore Design Challenge Learning resources** for our **Tech Tip: Materials Strategies for Engineering Design** (PDF and Video).

Test Area Set-up

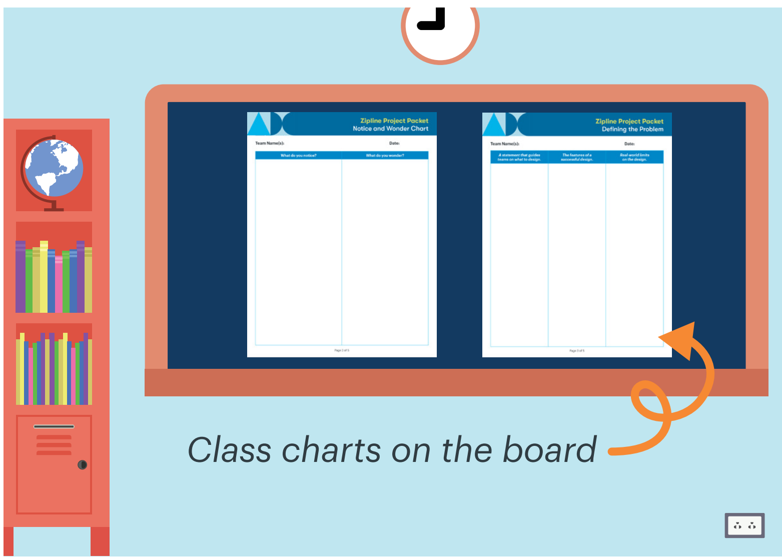
1. Set up your zipline and test it.
   - To set up your zipline, tie your string or cord to 2 objects about 10 ft (3.05 m) apart with a 5 ft (1.52 m) change in vertical height. We recommend creating 2 parallel lines so learners have multiple options for testing their device.
   - If using a stick or rigid item as your zipline, secure it at both ends, creating a 45-60 degree angle with the floor. Make sure to secure the rigid item using tape or string.
   - Zipline vehicles can travel quickly, so be sure to protect the landing zone with something soft like a pillow or blanket to prevent learners' vehicles from breaking.
2. *Safety Note:* Mark ziplines clearly to ensure there is no risk of anyone tripping or running into them.





Preparation

1. Gather, organize, and set out building materials and team supplies.
2. Print and staple the **Zipline Project packets**.
3. Set up the **Zipline Test Area** (see above for details).
4. Review the videos. Load both videos onto a device to view as a class.
   - **Zipline: An Engineering Story**, Tech Interactive, YouTube *(1:14 min)*
   - **Zipline commute: Columbia kids cross canyon to reach school**, WISE Channel, YouTube *(2:13 min)*
5. Create a **Class Notice and Wonder chart** on a piece of chart paper or the board.
   - See page 2 of the **Zipline Project packet**.
6. Create a **Class Defining the Problem chart** on a piece of chart paper or the board.
   - See page 3 of the **Zipline Project packet**.
7. Try out the activity yourself, with other educators, or learners you know. This will give you practice with the materials and tools to be able to anticipate student questions.



Adaptations for Distance Learning

For virtual learners designing devices from home, check out The Tech's **Lessons and Activities page** to find **The Tech at Home version** of our zipline activity and our **Educator Tips for Remote STEM Learning**.

Background Information

What is Sensemaking?

The National Science Teaching Association (NSTA) defines sensemaking as students "actively trying to figure out how the world works (science) or how to design solutions to problems (engineering)." In sensemaking classrooms, students do science and engineering by engaging in the science and engineering practices as part of a learning community.

In this activity, learners experience the phenomenon of ziplines transporting Columbian students to school. Students recognize a problem to solve: *"How do you slow the zipline cart's descent to keep it from crashing into the pole on the downhill end of the zipline?"* Students engage in practices to apply science ideas (forces) and engineering ideas (criteria and constraints) to design a tool, system, or process that slows the cart to help ensure students' safe arrival at school.

For more information on sensemaking, check out these **National Science Teaching Association resources**. Find more sensemaking tasks teachers and parents can use to engage their students in authentic, relevant science learning through the **NSTA Daily Do** webpage.

Frame the Challenge

Introduce the Phenomenon *(10 min)*

1. Ask for a couple of volunteers to share with the class how they got to school that day.
   - As each student shares, ask the rest of the class to share if that's the same way they got to school using thumbs up/down.
2. Tell students that you are going to share another way students get to school that might surprise them.
   - Pass out the **Zipline Project packets** and ask students to look at the **Notice and Wonder chart** (page 2).
   - Tell students that they are going to watch two videos that explore this phenomenon.
     - Ask students to record what they notice and wonder about the phenomenon as they watch the videos.
     - Refer students to the class **Class Notice and Wonder chart** you created on chart paper or the board. Let them know that you will be compiling all their observations here after the video.
   - Remind students they can use words and pictures to record their thoughts.
3. Play the videos.
   - First play the **Zipline: An Engineering Story** video to introduce the phenomenon to students.
   - Follow up by letting the students know that you will now show them the phenomenon in more detail, then play the **Zipline commute: Columbia kids cross canyon to reach school** video.
     - If this video is unavailable, refer to the **Zipline Commute handouts** (page 1) in their packets. Ask students to spend a couple minutes looking at the images and consider what they notice or wonder about the phenomenon.
4. Give students a couple minutes to finish writing down what they notice and wonder on their handout. Ask students to turn to their elbow partner and share at least one "notice" and one "wonder" with them.
5. Bring the class together.

Exploring the Phenomenon *(10 min)*

1. Invite the pairs to share what they noticed and wondered.
   - As students share, record their ideas, observations, and questions on the class **Class Notice and Wonder chart.**
2. Encourage students to share and connect their personal experiences to the phenomenon.
   - *Example: Ask students to consider a time when they were moving really fast.*
     - (i.e., riding a bike or an amusement ride)
   - *What made them feel safe during the experience?*
     - (i.e., seat belts, brakes, safety harness, ropes)
3. Facilitate an initial idea discussion about the science ideas behind the phenomenon. If seat belts or brakes make them feel safe, ask them to discuss how these features keep riders safe. Explore together how pushes and pulls (forces) interact when seat belts or brakes stop a body in motion.
   - Try using the example prompts in the **Sample Discussion Questions** to move students toward identifying a problem that needs to be solved.

Educator Note

While you can plan ahead of time what problem you want students to solve, be sure that students get the opportunity to arrive at that same conclusion on their own. Don't tell them that you want them to slow down the zipline device, instead use open-ended questions to guide their thinking so they genuinely see the need to solve that problem.

Sample Discussion Questions

The purpose of this discussion is to uncover students' ideas, build on those ideas to get to a class-identified problem to solve, and create some ideas for solutions.

Example Teacher Prompt	Sample Student Response
So we have this situation where students are ziplining to school. It seems like they get going pretty fast and it sounds like we feel safest when we have a way to slow down, like brakes and seat belts. Do we know what makes the zipline device move so fast?	It works because of **gravity**.
*We know gravity is a **force**, how does gravity affect the zipline rider?*	Gravity pulls on them.
Ok, gravity is pulling the zipline device down. Are there any other pushes or pulls on the device?	The air pushes on it? The line pulls it up? The rider pulls it down?
*Oh, air is pushing against the device, we call that **air resistance**. Can you think of anywhere else on the zipline where there might be objects pushing and pulling against each other?*	The rider pushes on the seat? When the zipline and the device are touching?
Yes. What pushes and pulls are happening where the zipline and the device touch?	The part of the device touching the zipline will be pulling down, while the zipline is pushing up against it.
Ok. It sounds like we have concerns about how fast a zipline device moves and there may be some pushes and pulls that we can use to slow down the device. Would it be helpful to explore the parts of the zipline for a few minutes before we start building?	Yes!

4. Wrap up the discussion by summarizing students' ideas (see above example).
5. Let students know that, now that they have an idea of a problem they want to explore, their next step is to investigate the zipline and available materials.

Materials Investigation *(15 min)*

1. Put students into teams of two or three, give them five minutes to investigate both the building materials and zipline.
   - Encourage them to continue capturing their thoughts in their **Notice and Wonder charts** (page 2).
2. Bring the class back together. Have them turn and share what they discovered with another student near them.
3. Ask for volunteers to share what they discovered with the class. Ask additional **Guiding Questions** to encourage more discussion.

Sample questions	Sample responses
Which materials might be suited for slowing the device?	• Something that catches the air. • Material touching the zipline shouldn't be too slippery.
Where could you attach your materials on the zipline or device so they push or pull on the device?	• Attach a hook to the cart so gravity can pull it down the zipline. • Add fabric to the attachment point at the bottom to slow the cart at the end.

   - As you record their answers in the class **Class Notice and Wonder chart**, help learners develop a shared understanding of science vocabulary by defining key terms together as they come up.
4. Invite learners to take the next step in testing their initial ideas by thinking carefully about the problem they want to solve and the criteria that will make their devices successful.

Developing Possible Solutions *(10 min)*

1. Let students know that engineers are people who design and build devices to solve problems. Today they are going to be engineers as they explore new zipline designs, but first engineers need to understand the problem they are solving.
2. Ask students to turn to the **Defining the Problem chart** (page 3) in their packets. Then point out the **Class Defining the Problem chart** on the board.
3. Lead students through defining the design problem, criteria, and constraints by asking guiding questions.
   - *First, we need to define the problem we're trying to solve. We need a clear statement to communicate about what we're going to design. Engineers call this a* **design problem**.

Sample questions	Sample responses
How might we explain what the need is?	• A device that can move down the zipline and reach the bottom slowly and safely.
Who is the user for this design?	• It's for children.
Does this sound right: A device that can carry children down the zipline to reach the bottom slowly and safely?	• Learners may suggest edits to the problem statement, such as only one child at a time, etc.

   - *Next, we need to think about what features or capabilities would make this a successful design. Engineers call these features and capabilities* **criteria**.

Sample questions	Sample responses
What are all the things our device needs to be able to do?	• It should slow to a stop on its own. • It needs a way to attach to the zipline. • It should hold the passenger the whole ride.
What will the passengers need?	• Ways to stay safe and comfortable during the ride.
How will we know if the device is successful?	• It slows to a stop. • Passenger is still inside at the end of the ride.

- *Finally, we need to identify what requirements or real-world limits exist on this design. These are things that are out of our control as designers, but still affect the design. Engineers call these "constraints."*

Sample questions	Sample responses
What are some examples of real-world limits designers have? What might keep you from creating the world's most amazing design?	• Time, materials, budget
If we don't have time to go searching for materials, what constraints do we have on our materials?	• We can only use what's available here.
Are there any other limits we have for this design problem? (Share with them how much time they will have to build.)	• Time!

4. Record student's ideas in the appropriate columns of the **Class Defining the Problem chart**.

Design Challenge

Prototype (Create and Test) *(30 min)*

1. Have learners consider the design problem, criteria, and constraints that they just defined. Give them two minutes of individual brainstorming time before continuing.
2. Next, have teams turn to the **Zipline Observation handout** (pages 4-5) in their packet. Remind them to test their design often and record their observations after each test.
3. Ensure teams know how much time they have to build.
4. Remind them to use the information they gathered during the materials investigation to guide their material and design choices.
5. Provide each team with a "passenger," (payload test item).
    - Remind learners that they will need to consider the needs of the passenger as defined by the class earlier in the criteria and constraints.
6. Send learners off to select materials and build. Set your timer for build time.
7. Circulate and encourage testing early and often. If students feel stuck or think their design will not work, they may learn something from seeing how even part of their design works on the zipline.

8. Support teams by helping them make additional observations during testing.

   For example:
   - Patterns: Learners should look out for patterns in their device's performance during testing. This can help them make informed decisions on the adjustments they will make on the next iteration of their design.
   - Cause and effect: Learners may notice that the speed of their device changes when different adjustments are made. Let them test repeatedly to explain the cause of these changes.
9. Support teams by asking open ended prototyping questions:
   - *How are you seeing the forces interact with your device?*
   - *How can you adjust your device based on what you observed?*
   - *What strategies are working so far to slow the device down?*
   - *Which of the criteria are you meeting right now? What ideas do you have to adjust the device?*
10. Always encourage iteration, even if the design is successful! Challenge teams to try testing their device three times in a row to see if it is reliable and has repeatable results.

Share Solutions *(15 min)*

1. At the end of the prototyping session, have the teams take turns sharing with the whole group about how their device performed during testing. Relate back to the phenomena and vocabulary as appropriate. Possible sharing questions could include:
   - *Share one thing that worked well and one thing that did not work well with your prototypes.*
   - *Which criteria did your device meet successfully?*
   - *Where did you see unbalanced forces in your design?*
   - *How would you change your device if you had more time?*
2. After each team shares, invite the other students to give positive feedback on their designs and encourage them to share suggestions.
   - I like how your design...
   - I wonder...
3. Help students celebrate after each group shares — even if their design fails! Emphasize the value of learning from failure in a group setting.

Debrief *(5 min)*

1. Have students look back on their charts from the beginning of the experience. Revisit the phenomena of the zipline videos and pair up teams to "think, pair, share" around what they learned. Possible **Debrief Questions** could include:
   - *What did you observe from your tests that helped you improve on your design?*
   - *What have we discovered about the needs of a zipline design?*
   - *If the zipline and your device were full size, would you want to ride in it?*

Real-World Phenomenon

Learners may have explored how to keep their passengers safe and comfortable while descending the zipline, but they may be wondering if this is the best alternative for the community. Engage learners in a big picture discussion by asking them to consider the broader context of the design problem. Show learners the video below and ask them to consider how they would change the problem statement with the addition of this new information.

Revisiting Colombia's dangerous and dizzying zipline to school, **WISE Channel, YouTube** *(4:18 min)*

Extensions

- **A New Angle:** Try changing the angle of the zipline and ask learners to investigate what is different about the test rig. Is the starting point higher or lower now? Is the zipline at a steeper angle? Encourage learners to reiterate based on how they think the changes may affect their device's performance.
- **Handle with Care:** Explore how changing the payload might affect their design. What if they were transporting something liquid, or very fragile items? Ask learners to consider what kinds of special features their device would need.

Next Generation Science Standards

Grades	Standard		Description
3	Performance Expectation	3-PS2-1	Plan and conduct an investigation to provide evidence of the effect of balanced and unbalanced forces on the motion of an object.
3-5	Performance Expectation	3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Vocabulary

For more tips on vocabulary and common engineering terms, check out the **Explore Design Challenge Learning page**, where you can find a variety of Tech Tips, videos, and downloadable resources.

- **Air resistance:** The force that acts in the opposite direction to an object moving through the air
- **Force:** Push or pull
- **Friction:** A push on an object in the opposite direction of that object's motion
- **Gravity:** The force by which a planet or other body draws objects toward its center
- **Incline:** A slant or slope
- **Payload:** Item(s) being carried by the device (cart)
- **Sensemaking:** The learner-driven process of actively trying to figure out how the world works (science) or how to design solutions to problems (engineering)

Team Name(s): **Date:**

What do you notice and wonder about this zipline?

Notice and Wonder Chart

Team Name(s): **Date:**

What do you notice?	What do you wonder?

Team Name(s): **Date:**

A statement that guides teams on what to design.	*The features of a successful design.*	*Real-world limits on the design.*

Zipline Observation Sheet

Team Name(s): **Date:**

Test #1	
Sketch your design. Show where the pushes and pulls (forces) are being used to slow the device. Label the materials you are using.	
What worked well?	*What could you adjust to better meet the criteria?*

Test #2	
What changes did you make to the design?	
What worked well?	*What could you adjust to better meet the criteria?*

Team Name(s): **Date:**

Test #3	
What changes did you make to the design?	
What worked well?	*What could you adjust to better meet the criteria?*

Test #4	
What changes did you make to the design?	
What worked well?	*What could you adjust to better meet the criteria?*